THE AARCMITTER-II
A VFO-CONTROLLED, 1.5 WATT TRANSMITTER FOR 160 METERS

Having had good results with QRP using my HW-8 on 80 meters this winter, I decided it was time to give 160 meters a try. I dusted off my AARCMITTER (Reference 1) and put it on the air, but quickly realized that being rockbound on 1932 kHz was not likely to result in many contacts. I considered purchasing a few crystals for the part of the band around 1810 kHz (the QRP calling frequency), but dismissed this idea when I discovered that general purpose crystals now cost about $11! A review of Solid State Design for the Radio Amateur (Reference 2), which provided the design for the original AARCMITTER, revealed that it should be possible to modify the transmitter for use with a VFO. The book also provided several examples of VFO designs that looked like they might be adaptable. Thus, I set out to design and build an outboard VFO for the AARCMITTER.

Rather than developing a printed circuit board, I decided to use "ugly construction" in which the circuit board foil is divided into squares using a hacksaw or Dremel tool, and components are mounted on top of the board. I cut a 2 1/4 inch by 6 1/2 inch piece of single-sided board (recommended for VFOs to minimize stray capacitances) and divided it into 3/8 inch squares, leaving a continuous, 3/8 inch wide strip on both of the long (6 1/2 inch) edges for V_{cc} and ground. I began by building and testing the oscillator on a breadboard and then transferred it to the circuit board. I continued this process adding buffer and driver amplifier stages until a thought I had enough output to drive the AARCMITTER's PA stage.

At this point I realized that I was only a few parts (and a couple of dollars) away from having a complete transmitter. I also had a couple of inches of room left on the end of my circuit board, so I decided that it would probably be easier just to duplicate the AARCMITTER's PA stage than to modify the original transmitter. This final step met with success. The result was, of course, the subject of this article: the AARCMITTER-II, a complete, VFO-controlled, 1.5 watt transmitter for 160 meters.

CONSTRUCTION DETAILS

Circuit board construction has been described above; my board is 6 squares wide by 17 squares long, except that the "squares" on the two long edges are actually continuous strips of foil for V_{cc} and ground. The 3/8 inch squares that I used make for fairly compact construction and could probably be relaxed to 1/2 inch or greater without impact. You might also want to start with a few more squares in the long direction (perhaps 20) as a margin of error. Any excess can always be cut off later. After the board was completed I mounted it on a 1 inch by 6 inch by 9 inch piece of pine board with sheet metal screws. Two "L" brackets were fashioned from thin sheet metal cut from a cookie sheet and used to support the air variable capacitor, vernier drive, and spot/shift switch. A 2 inch by 2 inch piece of double sided circuit board was mounted vertically and soldered in place between the VFO and the buffer stage for RF and

thermal isolation, and two phono jacks were mounted through 1/4 inch holes drilled through 1 inch squares of double sided board, which were then soldered in place vertically for the key and antenna connections. Two sheet metal covers were fashioned (again from a cookie sheet), one for the VFO stage, and one to enclose the rest of the transmitter. After final checkout and a few QSOs with stations in northern California all parts were removed, the pine board was stained and varnished, and everything was reinstalled.

CIRCUIT DESCRIPTION

The attached figure shows the final design of the AARCMITTER-II. L1 is wound on a toroid core for compactness and should be given two or three coats of Q dope for mechanical stability. (Q dope should be used on all of the toroid-wound inductors.) The diode-switched 5 pf capacitor is used to shift the VFO away from the transmit frequency while receiving. You can expect about 1 kHz shift per pf and any small value will do. I used 5 pf because I am using a general coverage receiver with a fairly wide bandwidth. A value of 80 pf for C1 will give a tuning range of a little over 100 kHz with the exact portion of the band determined by the adjustment of C2. (The best place for QRP activity is in the low end of the band.) Using a 100 pf air variable for C1 should allow you to tune from 1800 kHz to a bit above the AARC net frequency of 1932 kHz. Polystyrene or NP0 ceramic capacitors are recommended for the frequency determining portions of the VFO for stability.

The buffer stage uses shunt feedback for unity gain (see Reference 2) and is lightly coupled to the class A driver stage. Both of these techniques are used to prevent "pulling" of the VFO frequency when the transmitter is keyed. The driver amplifier deviates somewhat from the design I was using as a model in that provision is made for varying the output using a 200 ohm potentiometer. This was an experimental step, but was left in to make provision for "milliwatting" (if you are brave and/or crazy enough to try this on 160). The potentiometer could be replaced with a fixed resistor once the proper value of drive is determined (see below). T1 is a broadband transformer using a ferrite core material.

As discussed above, the power amplifier stage is essentially identical to the AARCMITTER, except for the capacitor at the base of the 2N3053 transistor, which was copied from another design where it was included for enhanced stability. It didn't seem to hurt, so I left it in. (You may want to experiment with this.) The Pi network is designed for 50 ohms input and output impedance, so a 50 ohm antenna should be used and the PA should be adjusted for a collector load impedance of 50 ohms. This is accomplished by noting that for a class C amplifier the load resistance, R_L, is given by $V_{cc}^2/2P_{out}$ (Reference 2 again). Thus, for a 50 ohm load, and given your particular value of V_{cc}, you should adjust the drive so that the PA output power, Pout, is equal to $V_{cc}^2/(2x50)$. For example, for a V_{cc} of 13.8 volts the drive should be adjusted for a final output of about 1.9 watts $((13.8)^2/(100))$.

The AARCMITTER-II was checked out on the bench and on the air with good results. An oscilloscope showed the output to be a pure sine wave with no detectable spurs or harmonics. On the air with a 3/8 wavelength end fed wire tuned with an L-network, the results were very satisfying. The first contact resulted in a 559 report from a station 550 miles away who had a 24 dB signal advantage. Best distance so far with good copy on the other end has been 800 miles. No attempt was made to incorporate the AARCMODULATOR (Reference 3) in this design since my specific need was for CW operation only, but I'm sure this could be done with little trouble.

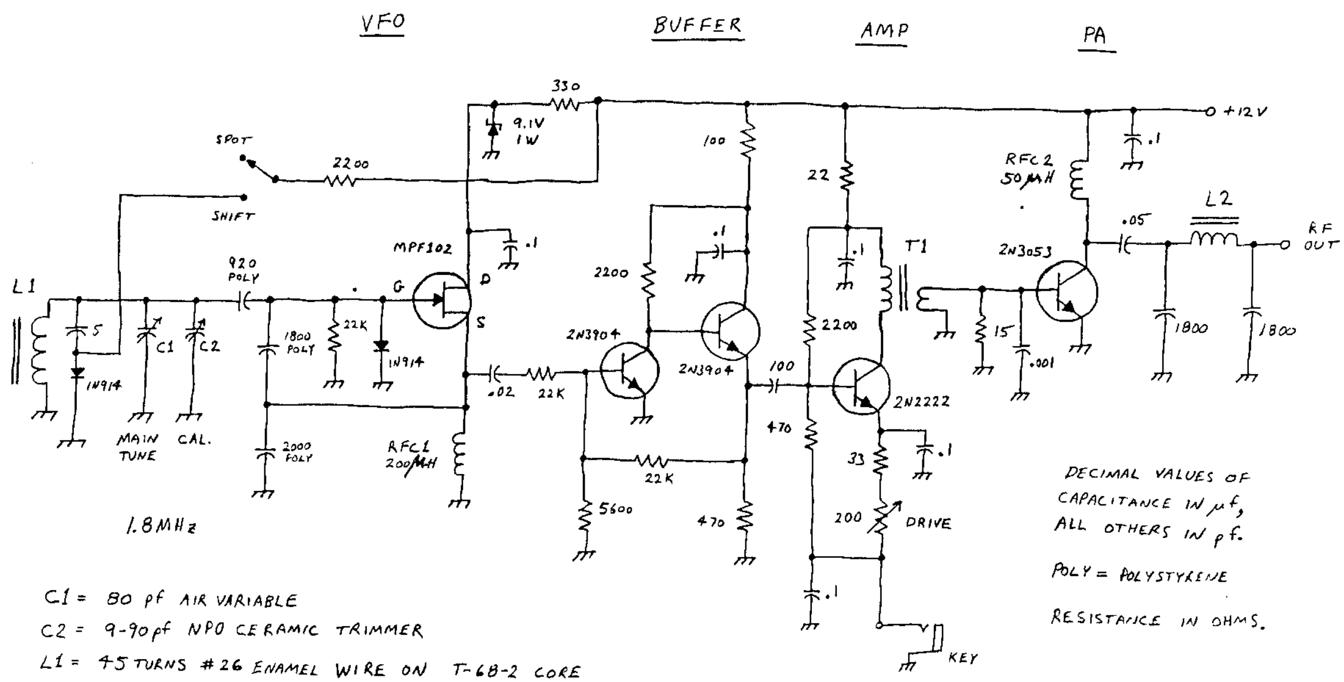
If you would like to experience the challenge of operating QRP on "top band," then I encourage you to give the AARCMITTER-II a try. I would be glad to answer any questions you might have regarding the design or construction of this project. I would like to gratefully acknowledge the contribution of Jim Larson, KF7M, who assisted with bench checkout of the final design. Thanks also to KA8TER for advice and encouragement, and to N7VVG for help with the first on-air test transmission.

REFERENCES

1. The AARC-MITTER 160 Meter Transmitter, Argonne Amateur Radio Club, K9CZB and W9GBL, 1988

2. Solid State Design for the Radio Amateur, American Radio Relay League, Inc., W7ZOI and W1FB, 1977

3. The AARC-MODULATOR Amplitude Modulator for the 160 Meter AARC-Mitter Transmitter, Argonne Amateur Radio Club, K9CZB and W9GBL, 1988



C1 = 80 pf AIR VARIABLE

C2 = 9-90pf NPO CERAMIC TRIMMER

L1 = 45 TURNS #26 ENAMEL WIRE ON T-68-2 CORE

L2 = 30 TURNS #26 ENAMEL WIRE ON T-50-2 CORE

T1 = 25 TURNS PRIMARY, 4 TURNS SECONDARY ON FT-37-61 CORE

RFC2 RATED FOR 500 mA

DECIMAL VALUES OF CAPACITANCE IN μf, ALL OTHERS IN pf.

POLY = POLYSTYRENE

RESISTANCE IN OHMS.

AARCMITTER -II
de KR8L
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